National Spatial Data Infrastructure

Vegetation Classification Standard

Vegetation Subcommittee
Federal Geographic Data Committee

June 1997

Federal Geographic Data Committee

Established by Office of Management and Budget Circular A-16, the Federal Geographic Data Committee (FGDC) promotes the coordinated development, use, sharing, and dissemination of geographic data.

The FGDC is composed of representatives from the Departments of Agriculture, Commerce, Defense, Energy, Housing and Urban Development, the Interior, State, and Transportation; the Environmental Protection Agency; the Federal Emergency Management Agency; the Library of Congress; the National Aeronautics and Space Administration; the National Archives and Records Administration; and the Tennessee Valley Authority. Additional Federal agencies participate on FGDC subcommittees and working groups. The Department of the Interior chairs the committee.

FGDC subcommittees work on issues related to data categories coordinated under the circular. Subcommittees establish and implement standards for data content, quality, and transfer; encourage the exchange of information and the transfer of data; and organize the collection of geographic data to reduce duplication of effort. Working groups are established for issues that transcend data categories.

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1. INTRODUCTION

The United States Federal Geographic Data Committee (hereafter called the FGDC) is tasked to develop geospatial

National Spatial Data Infrastructure (NSDI), acting under the Office of Management Budget (OMB) Circular A-16 and Executive Order #12906.   FGDC subcommittees and working groups, in consultation and cooperation with

quality, and transferability of geospatial data. FGDC standards are to be developed through a structured process, integrated with one another to the extent possible, supportable by the current vendor community (but are

At present there is no Federal standard for vegetation classification and reporting of vegetation statistics. However, there is broad recognition of the need to establish national definitions and classification standards that will

standard for terminology, core (or minimum) data and vegetation classification.

There is no single agency responsible for classifying, describing, and/or mapping the vegetation cover of the

vegetation/land use types (e.g., forest, rangelands, wetlands, agricultural lands) or by mission and jurisdiction (e.g., National Forests, Public Lands, National Parks, National Refuges). This has resulted in the current condition of

in direct conflict with each other due to differing definitions and protocols. The present situation has prevented development of a national synoptic view of the vegetation resources of the United States. Federal agencies are

duplication. The NVCS responds to this direction.

2. OBJECTIVE

consistent national vegetation classification to produce uniform statistics in vegetation resources from vegetation cover data at the national level. It is important that, as agencies map or inventory vegetated Earth cover, they

Adoption of the NVCS in subsequent development and application of vegetation mapping schemes will facilitate the compilation of regional and national summaries. In turn, the consistent collection of such information will

analysis at the field level.

The standard presented represents more the minimum required than the ideal or maximum. The purpose of the

the same across all federal agencies to permit aggregating data from all federal agencies. The NVCS does not prevent local federal efforts from doing whatever they want to meet their specific purposes. NVCS does require

provide the required core data.

3. MAINTENANCE AUTHORITY

The United States Department of Agriculture - Forest Service was assigned responsibility to coordinate vegetation data-related activities under the policy guidance and oversight of the FGDC. The enclosed draft National Vegetation Classification Standard was developed under the authority of the Office of Management and Budget Circular A-16, revised 1990. The standard is based on earlier work of United Nations Educational Scientific Cultural Organization (UNESCO 1973) and Driscoll et al (1984) that was refined by The Nature Conservancy (TNC Ecology Working Group 1997 (in prep)) for conservation planning. The FGDC Vegetation Subcommittee is coordinating with the United Nations Environment Programme/Food and Agriculture Organization (Young 1994, UNEP/FAO 1995, and Di Gregoiro and Jansen 1995) to have the NVCS as a model for a potential global standard to characterize earth (land) cover.

4. STANDARDS DEVELOPMENT PROCEDURE

Vegetation is comprised of a collection of plants or plant communities with distinguishable characteristics that occupy an area of interest and about which data can be arrayed in a standard format. These vegetation data can provide information about a significant portion of the earth's surface. A Subcommittee on vegetation data (FGDC Vegetation Subcommittee, hereafter called the Subcommittee) was established to promote the use of documented standards in data collection and reporting concerning vegetation that is financed in whole or in part by Federal funds; to exchange information on technological improvements for collecting vegetation data; to encourage the Federal and non-Federal community to identify and adopt standards and specifications for vegetation data; and to collect and process the requirements of Federal and non-Federal organizations for vegetation data.

The Subcommittee consists of representatives designated by the Federal agencies that collect, or finance the collection of, vegetation data as part of their mission or have direct application of these data through legislated mandate. The subcommittee provides interagency policy oversight. FGDC will need to maintain the subcommittee to ensure ongoing interagency coordination, system evolution, and policy interpretation and development. Organizations having national vegetation classification and mapping responsibilities are also represented.

Current membership of the Subcommittee includes representatives from:

- U.S. Government
    - Department of Agriculture (USDA)
        - Forest Service (FS) - Chair
        - National Agriculture Statistical Service (NASS)
        - Natural Resources Conservation Service (NRCS)
    - Department of Commerce (DOC)
        - National Oceanic and Atmospheric Administration (NOAA)
        - National Marine Fisheries Service.
    - Department of Defense (DOD)
        - Tri-Service Technology Center
        - U.S. Army Corps of Engineers (USACERL)
    - Department of Interior (USDI)
        - Bureau of Land Management (BLM)

Bureau of Indian Affairs (BIA)
Fish and Wildlife Service (FWS)
National Park Service (NPS)

U.S. Geological Survey (USGS)
Environmental Protection Agency (EPA)
National Aeronautics and Space Administration (NASA)

- Non U.S. Government
  The Nature Conservancy (TNC)
  Ecological Society of America (ESA)

The Subcommittee identified a need to establish a hierarchical classification standard and associated information standards that will contain an organized list of vegetation types (taxonomic units) with identified relationships among them. Procedures used to identify these standards included users surveys, periodic Subcommittee meetings, a vegetation classification forum held in 1995, and an informal review of the draft standards by the agencies and organizations represented on the Subcommittee. All decisions were made by consensus.

This document proposes a vegetation classification standard and set of information standards to be used by Federal agencies in their activities for inventory, mapping, and reporting on the vegetation resources of the United States. It includes a description of the National Vegetation Classification Standard, general policy regarding federal agencies' use, suggested applications, the principles (basic ideas, requirements) that guided the development of this standard, and a list of definitions used in the standard and its development. This document does not detail the floristically defined units of the classification standard, the field methods, or the data management and analysis standards that will be required to develop and maintain this National Vegetation Classification Standard. This information will be presented in subsequent documents by the Subcommittee.

The National Vegetation Classification Standard (NVCS) is an evolution of what TNC has already developed, which, in turn, is an evolution from other standards, including past federal government and UNESCO (1973) efforts. The NVCS is compatible with TNC because it has evolved from original TNC efforts and TNC now is using NVCS. Once adopted by FGDC, NVCS will be the federal standard. It will guide federal efforts to classify vegetation.

The goal of the NVCS is to provide a standard for meeting the FGDC requirements while at the same time not interfering with the local actions needed to meet local purposes or the bureau actions needed to meet bureau purposes. The NVCS requires federally supported vegetation classification activities to collect data in ways that permit the data to be useful for creating a classification according to NVCS requirements without preventing the activities from also collecting data to meet their local or bureau purposes and requirements.

This standard deals with vegetation cover. It consciously seeks to avoid land use terms. At the same time, it seeks to be useful to efforts to describe and map land use. The NVCS overlaps the Wetlands standard in wetland and emergent aquatic regions. The NVCS classifies primarily according to vegetation and floristic characteristics, not to habitat or related characteristics, whereas the Wetlands standard includes soils and other habitat characteristics in its classification determinations. The two standards have different purposes and so the classifications of the two standards should be viewed as complementary but different systematic approaches or layers in an overall analysis of a geographic area.

5. PURPOSE and SCOPE :

- Fosters accuracy, consistency, and clarity in the structure, labeling, definition and application of a systematic vegetation taxonomy for the United States. Accuracy, consistency, and clarity are critical for making effective and efficient decisions about complex assemblages of biotic organisms.

- Establishes a national set of standards for classifying existing vegetation cover and its associated information for the United States and its Trust Territories that will be used by Federal agencies to develop and report national statistics. This standard includes guiding principles, definitions of important terminology, and the National Vegetation Classification Standards (NVCS).

- Develops federal minimum metadata requirements to ensure consistent reporting on the status of our Nation's vegetation resources. Both the classification standard and the metadata requirements may be used nationally to link local level vegetation inventory and map efforts

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5.1. Expectations - The intention of this Federal Geographic Data Committee National Vegetation Classification Standard is to build a common data base of vegetation cover that the various federal agencies will cooperatively populate with consistent and credible data. As state, county, reservation, and private agencies inventory or map lands within the United States, they should collect core data required to meet this standard and populate a national data base on existing vegetation. Agencies must be able to report their vegetation data according to this national standard, although it is understood that agencies will also use other classification approaches according to their respective agency needs and missions. Crosswalks between agency-specific schemes, as well as conventions and protocols for vegetation mapping will be developed through the use of the standards (for examples, see Section I).

5.2. Policy - These standards are intended to be used by federal agencies and as needed by other groups including those engaged in land use planning or management by county and state governments, teaching or research uses, and by the private sector. Widespread use of these standards will facilitate integration of Earth cover data collected by diverse users into a common national data base, enhancing utility beyond single projects and establishing a long-

The adopted standards must be followed by all Federal agencies for data collected directly or indirectly (through grants, partnerships, or contracts). Currently the policy for applying the standard is only through the formation level. Agencies are encouraged to aid in the development of the alliance and association levels through participation in developing the national data base and support for the professional review panel. Non-federal organizations of any and all types might find it useful to use the standard to increase the compatibility of their efforts with those of nearby federal land managers and/or to make their efforts more compatible in any activities that involve them with federal agencies.

5.3. Guiding Principles - The following principles were used to develop the National Vegetation Classification Standard:

- The classification is applicable over extensive areas.

●   The vegetation classification standard is compatible, wherever possible, with other Earth cover/land cover classification standards.

●   The classification will avoid developing conflicting concepts and methods through cooperative development with the widest possible range of individuals and institutions.

●   Application of the classification must be repeatable and consistent.

●   When possible, the classification standard will use common terminology (i.e., terms should be understandable and jargon should be avoided).

●   For classification and mapping purposes, the classification categories were designed to be mutual exclusive and additive to 100% of an area when mapped within any of the classification's hierarchical levels (Division, Order, Class, Subclass, Subgroup, Formation, Alliance, or Association). Guidelines have been developed for those instances where placement of a floristic unit into a single physiognomic classification category is not clear. Additional guidelines will be developed as other such instances occur.

●   The classification standard will be dynamic, allowing for refinement as additional information becomes available.

●   The NVCS is of existing, not potential, vegetation and is based upon vegetation condition at the optimal time during the growing season. The vegetation types are defined on the basis of inherent attributes and characteristics of the vegetation structure, growth form and cover.

●   The NVCS is hierarchical (i.e., aggregatable) to contain a small number of generalized categories at the higher level and an increasingly large number of more detailed categories at the lower levels. The categories are intended to be useful at a range of scales (UNEP/FAO 1995, Di Gregorio and Jansen 1995).

●   The upper levels of the NVCS are based primarily on the physiognomy (life form, cover, structure, leaf type) of the vegetation (not individual species). The life forms (e.g., herb, shrub, or tree) in the dominant or uppermost stratum will predominate in the classification of the vegetation type. Climate and other environmental variables are used to help organize the standard, but physiognomy is the driving factor.

●   The lower levels of the NVCS are based on actual floristic (vegetation) composition. The data used to describe Alliance and Association types must be collected in the field using standard and documented sampling methods. The Alliance and Association units are derived from these field data. These floristically-based classes will be nested under the physiognomic classes of the hierarchy.

6. NATIONAL VEGETATION CLASSIFICATION STANDARD

The NVCS provides a standard framework and classification approach for natural, semi-natural, planted and cultivated vegetation types. All areas having equal to or more than 1% of the surface area with live vegetation cover are classified within the NVCS. The vegetation classification standard is hierarchical and combines floristics at the lowest levels and physiognomy and broad ecological modifiers at the highest levels of the hierarchy. This approach allows the characterization of vegetation patterns at multiple spatial scales. Cultivated and managed vegetation types are included in this classification standard due to their extensive geographical

coverage and the importance of identifying, mapping, and monitoring these types. In addition to vegetation found on strictly upland environments, this classification includes wetland vegetation (rooted emergent and floating).

The NVCS is largely the result of modifications to the vegetation classification standard compiled and refined for conservation planning and resource management at The Nature Conservancy (TNC Ecology Working Group 1994, 1997 (in prep)). The upper five physiognomic levels of the TNC standard (Class, Subclass, Group, Subgroup and Formation) are based on modifications by TNC Ecology Working Group of the UNESCO (1973) and Driscoll *et al*. (1984) vegetation classification. The lower two floristic levels (Alliance and Association) have been developed and are periodically enhanced by the ongoing work of TNC and the network of State Heritage Programs (TNC Ecology Working Group 1997 (in prep)).

The UNESCO system was modified and refined to provide greater consistency at all hierarchical levels and includes additional physiognomic types. A few of the inconsistencies inherent to the UNESCO standard were left intact where modification would have compromised the ecological integrity of the classification standards.

This classification scheme for the upper levels of the hierarchy was chosen because:

- It is already the product of an international group of experts. As a result, it is worldwide in coverage and is a more readily acceptable product than local and/or single-authored standards. Variations of the standard are presently being used by different agencies in the United States and internationally.

- It is a hierarchical standard that was designed for classification and mapping at multiple scales.

- It was well suited to have floristic units nested under its lowest level.

- The structure of the standard makes it open-ended; units meeting the standard can be added as needed.

There are seven upper levels in the NVCS. Physiognomic class is a level that is defined by life form and percent cover of the vegetation strata. The level of physiognomic subclass is determined by the predominant leaf phenology of woody plants and the leaf type and periodicity of herbaceous plants. The physiognomic group is defined by a combination of factors relating to climate, leaf morphology and leaf phenology. The subgroup separates the Natural/Semi-natural types from the Planted/Cultivated types. The formation level identifies ecological groupings of vegetation units with broadly defined environmental (e.g., hydrology) and additional physiognomic factors.

The hierarchy for the NVCS is presented below.

NATIONAL VEGETATION CLASSIFICATION STANDARD

DIVISION
    ORDER

        PHYSIOGNOMIC CLASS
           PHYSIOGNOMIC SUBCLASS
            PHYSIOGNOMIC GROUP
            SUBGROUP
physiognomic levels   FORMATION

floristic levels   ALLIANCE
                ASSOCIATION

The physiognomic and environmental characteristics used to describe the physiognomic units differ among the major groupings of vegetation. For example, some of the variables used to classify woody formations are different than the variables used to classify herbaceous formations. Adherence to a strictly parallel set of classification variables would cause inappropriate ecological distinctions to be made. Even within a given Physiognomic Group, some variables are better for describing certain vegetation types than others. For example, within the temperate needle-leaved evergreen closed tree canopy group, crown shape is an important variable for distinguishing major floristic types within the upland types, but this distinction is not particularly useful for separating floristic types within wetland types. Different variables are used as necessary to provide the most ecologically meaningful groupings possible and to limit arbitrary splitting of floristic units

There are two floristic levels in the NVCS. Alliances represent an aggregation of Associations and are characterized by one or a group of diagnostic species which, as a rule, occur in the dominant or uppermost stratum of the vegetation. The finest floristic unit of the classification standard is the Association which is characterized by diagnostic species that occur in all strata (overstory and understory) of the vegetation. The diagnostic species used to determine both the Alliance and Association are primarily the dominant species. When data indicate that additional diagnostic species (including differential, indicator, or character species) provide a better characterization of ecological patterns, they are used in addition to the dominant species to classify these floristic units. The current list of Alliances and Associations for the conterminous United States will be published by The Nature Conservancy in the spring of 1997 (TNC Ecology Working Group 1997 (in prep)).

Classification requires that fixed categories be imposed on naturally continuous systems. The cover values, height cutoffs and other physiognomic and environmental distinctions in the classification (taken largely from UNESCO 1973 and Driscoll *et al.* 1984) were chosen to best represent the ecology of vegetation and to provide a consistent framework for describing vegetation across the United States. While not arbitrary, these values may not perfectly describe the variable ecological patterns inherent to some types of vegetation. When the characteristics of a given floristic type span more than one physiognomic unit, the floristic type is placed intact in the physiognomic unit that best describes the majority of occurrences of the floristic type. Floristic units are only split and placed in more than one physiognomic unit if there is evidence that the physiognomic differences also reflect true floristic differences.

The physiognomic attributes in the classification are designed to describe the characteristics of the vegetation as a

whole, not the characteristics of individual species. For example, willows and alders exhibit shrub characteristics in many areas and tree characteristics in other areas. Where the overall physiognomy of the vegetation which includes willows and alders is multi-stemmed, the type is classified as shrub dominated. Where the overall physiognomy of the vegetation which includes these species is single-stemmed, the type is classified as tree dominated (provided this reflects additional floristic differences).

The combined physiognomic/floristic approach of this classification standard allows identification of units from both a "top-down" (divisive) and "bottom-up" (agglomerative) approach. The top-down approach allows the use of physiognomic distinctions to help map vegetation, to stratify sampling and, where floristic information is lacking, to delimit vegetation units. A bottom-up approach requires that field inventory and floristic analysis are the primary means for defining associations. Where physiognomy is variable, the bottom-up approach can also be used to help to determine the important physiognomic distinctions.

Sparsely vegetated land cover units are classified within this standard because they cover significant areas across the United States and comprise unique and recognizable vegetation types. The upper hierarchical levels of the sparsely vegetated types are based on physical characteristics of the landscape. Remote sensing approaches can be used to map such areas and provide a functional stratification for inventory of the vegetation types. The lower levels of the classification standard are based on the floristic associations similar to the rest of the classification framework. This Subcommittee will work with the newly formed FGDC Earth Cover Working Group to determine a compatible approach to the upper levels of the sparsely vegetated classes.

Assigning a vegetation 'stand' to a classification type at each level of the classification hierarchy requires a defined set of information. The vegetation types in the NVCS may be developed through the analysis of imagery, thematic spatial data layers, and field survey data. More and more detailed data are required to derive units at consecutively finer levels of the classification hierarchy. Standard inventory methods must be followed and documented to identify the sample points, and uniform data collection protocols must be followed to ensure consistency and comparability of the field data. The standards for vegetation inventory, data management and analysis will be completed as a future stage of work by this Subcommittee.

The upper seven physiognomic levels of the classification standard appear in Appendix I. Appendix II gives examples of vegetation types fully classified within the system. The terminology associated with each level of the hierarchy is included in the "Definitions" section in Appendix III.

6.1. Application - The National Vegetation Classification Standard will enable federal agencies to collect and report vegetation information in a standard format and apply a standard classification standard in the attribution of spatial vegetation data and to use standard vegetation units in reports and on maps. This classification is a critical support tool for inventory, monitoring, research, management, and planning of biological resources and it is currently an aid in strengthening these activities at the national and state levels. The standards do not dictate values for several mapping-related parameters such as minimum mapping unit, polygon minimum width thresholds, etc.. Rather, the NVCS should be employed using the most appropriate level(s) in the hierarchy, in concert with application-specific mapping protocols which provide for the retention of appropriate information. In this manner, as agencies map vegetation at the level(s) and resolution(s) required by their programs, they are generating data which may be shared and assembled into a larger data base of comparable vegetation information.

This standard was designed to be useable in a wide variety of situations and thus its application is not dependent on any specific data inputs, resolutions or mapping scales. This is one of the inherent values of a hierarchical classification standard. A user must have detailed information about a vegetation stand(s) in order to classify it at

the lowest floristic levels but lacking such detailed information, the user can still assign the required more general classification at one of the higher physiognomic classes in the hierarchy. The standard is applicable for many types of data inputs and resolutions and mapping scales. Thus any specific categorization breakout and detail in the hierarchy would obviously depend on the type of data inputs. Data inputs could range from detailed ground observations of very localized vegetation with GPS locations to high, medium, and coarse resolution remote sensing inputs such as 1 meter to 1 kilometer, some with little or no ground observations.

The application of this standard for national, regional and State analyses, reports, and maps will be particularly beneficial by providing a cohesive, consistent, synoptic view of the vegetation resources of such broad geographic areas. Examples of major activities which will benefit directly or indirectly from such a unified classification and information standard include fire fuels mapping and management and general fire fighting, wildlife management, forestry and grazing planning and management, general land use planning and environmental impact assessments, biodiversity and ecosystem management and conservation, and many other natural resources management issues.

This uniform NVCS should also complement local classifications that are designed to meet more specific objectives.

The specific application of this standard to any mapping activities is dependent on the goals and objectives of the mapping activities. Issues of scale, minimum mapping area, appropriate level in the classification standard to use, etc. are all specific to each individual mapping effort. The classification standard merely sets a hierarchical list of classes that should be intelligently employed by the user based on the specifications and limitations of their particular mapping program. The program examples described in Section I, "Current Use of the National Vegetation Classification Standard", all vary with regard to mapping program specifications and limitations and yet all employ the NVCS.

The upper physiognomic levels of the classification hierarchy (see Appendix I) are based on factors that are generally discernible from imagery or ground verification. The types of information needed to categorize vegetation stands from the Physiognomic Class through the Formation levels are referred to in the Requirements Section of this report.

The floristic levels of the classification hierarchy are determined from field data concerning the structure, composition, and cover of the vegetation. Information that is required to categorize vegetation stands into national classification types at the Alliance and Association levels is acquired using standardized inventory methods by characterizing the whole vegetation stand and by plots within the stand. The information needed to classify vegetation into floristic units is listed in the Requirements Section of this report.

It is presently more complicated to assign a vegetation stand to a floristic level of the hierarchy than to a physiognomic level of the hierarchy. While the standard must be considered dynamic and subject to change as new information becomes available, it is anticipated that the higher physiognomic levels of the classification are considerably more stable at this time. A comprehensive list of the nation's floristic level vegetation types is currently a goal to be pursued in the long term application of this standard. The first approximation of a national list of vegetation types across all levels of the classification hierarchy will be published by The Nature Conservancy (TNC Ecology Working Group) in 1997. This publication will serve as the initial basis for assigning vegetation stands to types within the NVCS. This initial national list of vegetation types is the result of several years of work accomplished at the local level in conjunction with private, State and Federal agencies and organizations. With the collection of standardized data, all users needing to classify a stand will eventually be able to input enter their data into a national data base on existing vegetation (as mentioned in Section D). This national data base will be

accessible over the Internet and will be searchable and browsable with photographs, descriptions, successional status and relationships, and data for users to review the development and status of the NVCS. It will also provide a useful tool to aid users in assigning the appropriate classification to their particular vegetation stand data.

A process to help users classify vegetation at the lowest floristic levels will be developed in the future involving Federal, State, and private agencies and professional organizations . When a classification is questionable and a confidence assignment is required, a copy of the vegetation data may need to be sent to the FGDC Vegetation Subcommittee or a professional advisory panel authorized by the Subcommittee for review and assistance. The

Subcommittee or the authorized professional panel will ensure that the vegetation is classified within the NVCS at the appropriate level and type within the classification hierarchy.

- Links with Remote Sensing

    The focus of the NVCS is on classifying vegetation, not on the currently available tools for producing the classifications. The use of remote sensing platforms and ground-truthing practices are some of the techniques by which one develops the data to permit the classification.

    Size class and structure information to support many remote-sensing based classifications have to come from ground-truthing. The long term goal is to increase the accuracy of the vegetation classification, no matter what scale of remote sensing is used.

    Landsat TM can only be reliably used to interpret Alliances when field and aerial observations are also used. Significant advancements have been made in the last two years using multi-seasonal TM (thus gaining better pattern delineation by way of phenotypic distinction) in combination with aerial videography. It is unlikely that many Alliance types could be distinguished by single-date TM and no other ancillary information.

- Links with Scale

    The NVCS is a vegetation classification standard. As such, it is scale independent. The scale a classifier chooses to use for presenting the mapped image of the classification will depend on the classifier's needs for detail versus broad coverage and the choice of sensing and ground-truthing systems the classifier makes for obtaining the raw data. The NVCS has no role to play in developing availability of remotely sensed data.

    The level of field and other efforts will be determined by the scale of classification chosen. It is not required that all vegetation classification efforts must classify to Association or Alliance.

6.2. Current Use of the National Vegetation Classification Standard - In addition to the broad application of this classification standard for conservation planning and biodiversity management by the Nature Conservancy and network of State Heritage Programs, the NVCS is currently being used and refined through TNC's work with numerous national level Federal programs for resource inventory, management, monitoring and conservation. Examples of these applications are listed below.

The USGS Gap Analysis Program (GAP) uses the NVCS for vegetation classification in mapping the natural and semi-natural vegetation of the U.S. in order to assess the conservation status of species and their habitats. The program's vegetation mapping methods use satellite imagery as a convenient meso-scale base map as well as a source of land cover information. Other sources of land cover information include field observations and aerial

video and photography. The progenitors of the NVCS (UNESCO 1973, Driscoll et al 1984, TNC 1994) were the only standards that met the necessary criteria for GAP when the program began working cooperatively with other organizations to develop a unified vegetation classification standard (Jennings 1996).

Since 1990, GAP has funded TNC regional ecologists to collect, evaluate, and classify described Alliances from state Natural Heritage Programs into regionalized classifications. The program first funded this work for the TNC Western Region in 1990 (Bourgeron and Engelking 1993), and then continued to support work in the Northeast (Sneddon and Anderson 1994), Southeast (Weakley et al 1996) and Midwest (Faber-Langendoen and Drake 1996). The Gap Analysis Program currently has active or completed projects in 44 states.

As part of the National Park Service Inventory and Monitoring Program, the USGS/NPS Vegetation Mapping Program is currently involved in a long-term project to map the vegetation of all park units using the standard NVCS. This program requires the mapping of vegetation according to the NVCS using a minimum mapping unit of 0.5 hectare (about 1 acre) mapped to a standard 1:24,000 scale USGS topographic quadrangle. Alliances or Associations must be assigned to each vegetation polygon delineated. All vegetation maps, associated vegetation plot data, and accuracy assessment points are geographically referenced and made available in digital form that is GIS compatible. Inventory and mapping activities are currently taking place in Arizona, California, Maryland, Michigan, Minnesota, Nebraska, South Carolina, South Dakota, and Tennessee.

The U.S. Fish and Wildlife Service is interested in applying the same classification and mapping standards as the USGS/NPS Vegetation Mapping Program for the wildlife refuge system. The Nature Conservancy is presently mapping the vegetation of Chincoteague National Wildlife Refuge as a pilot project. The minimum mapping unit is 0.5 hectare, and the vegetation will be mapped to the Alliance and/or association level. The refuge envisions numerous applications for the vegetation information including improved management of their shorebirds, endangered species, invasive weeds, and ponies. Beyond the Chincoteague National Wildlife Refuge (NWR) pilot, the Service believes that identifying vegetation communities throughout the NWR system will improve the management of the standard fish and wildlife resources.

The Nature Conservancy is presently mapping the Connecticut River for the USGS Ecosystem Initiative to identify critical migration forest bird habitat that should be included in the Conte Wildlife Refuge System. This mapping and analysis is being carried out at the Alliance and Association levels of the NVCS. TNC has performed both full vegetation inventories and targeted analysis of rare communities on numerous Department of Defense installations across the United States. Many of these projects have been associated with the DOD Legacy Program. All of this work has been based on the NVCS.

Perhaps the oldest use and support of the NVCS has been from the U.S. Forest Service. This classification is used to describe the existing and potential vegetation for the ecoregional subsections in the Eastern and Southern Regions.   This information is used for determining management and conservation goals. The classification was the basis for the ecological assessment that was carried out in the Pacific Northwest Region Columbia River Basin.

The Southern Region plans to replace the timber typing standard with the NVCS, and use this standard as the lowest level of the ecological classification standard of existing vegetation. In ecosystem management, the USFS plans to use the classification and ranking standard as a guide for management and conservation action. The California Region is carrying out a LANDSAT change detection program that is cross-walked to the NVCS.   In addition, projects in the Ozark Highlands, the Northern Great Plains, the Southern Appalachians, and the Great Lakes States are using this classification as the basis for mapping and analysis.

There are many other agencies using the NVCS. For example, the Bureau of Land Management is cross-walking to this classification standard for an interagency classification project in southwest Colorado. The NVCS provides the framework for vegetation mapping and analysis of numerous riparian projects that The Nature Conservancy is implementing for the Environmental Protection Agency. The Multi-Resolution Land Characterization Consortium has also identified this classification standard as a common basis for vegetation mapping.

7. REQUIREMENTS

The National Vegetation Classification Standard developed by this Subcommittee needs to be compatible with the standards that are being developed, in particular, by the Wetlands Subcommittee, Soils Subcommittee, and the Earth Cover Working Group. The NVCS does not preclude application of the data to other classification standards, but does require that federal applications produce data that support being able to conduct a classification according to the NVCS. Standards developed by this Subcommittee will need to be reflected in the FGDC Content Standards for Digital Spatial Metadata.

NVCS identifies the minimum that must be done. NVCS sets a national minimum standard for federal actions to ensure compatible and appropriate coordination across federal agencies. It does not prevent other actions, as well.

Most existing vegetation inventory/classification data bases may be cross-walked to populate the uniform NVCS. It is not the intent to throw out previous work and redo inventory. Each agency will need to consider the utility of the NVCS for meeting their unique needs and decide to retain existing inventory standards beyond what the NVCS delivers or where the NVCS fits their needs, adopt the NVCS. Regardless of their decision, each agency is to populate the NVCS data base to provide a uniform picture for the vegetation of the United States. Agencies shall use all available tools for accurate classifications.

Applying the National Vegetation Classification Standard requires two separate but interrelated activities:
- data collection and management for vegetation classification and reporting at different levels of the hierarchy, and

- management and reporting of vegetation information associated with vegetation maps.

7.1 Data Collection - Data Collection to Describe Taxonomic Units of the Classification Standard: Agencies will adhere to common, professionally accepted field inventory and data collection methods that must be documented in associated metadata (data about the data). One should incorporate existing information where possible. However, it is imperative to plan new data collection efforts within the context of the NVCS. This access will likely be through the national data base of existing vegetation described elsewhere in this standard.

- Field samples with plot data used for describing or characterizing standard vegetation types must be collected within homogeneous stands of the vegetation types being described.

- The sample size and mapping size must be determined by the purpose of the classification effort and the kind of sampling data that are available to the classifier. Sampling procedures and methods must comply with recognized professional standards that will ensure the collection of core physiognomic, biological, locational and environmental information. The amount of data collected may be determined by the level of classification required to meet the objectives of a particular project.

All field work will be expected to obtain the core data listed below. By doing so, others will be able to use the results to develop, without duplication of field work, the higher levels of classification that will be useful to them. Core data that may be required to classify units down through the physiognomic levels of Class, Subclass, Group and Formation include:

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> Dominant life form (i.e. tree, shrub, dwarf shrub, herb, non-vascular) and general percent cover class of the dominant vegetation stratum.

> Physiognomic attributes of the dominant vegetation stratum (e.g., evergreen, deciduous, etc.)

> Hydrologic regime of the vegetation site (Cowardin 1979)

The additional core data that will be required to classify units down to the floristic levels of Alliance and Association include:

> Height class of vegetation strata (in meters)

> Dominant and indicator plant species by stratum and percent cover class estimate. Agencies will use the scientific names (nomenclature) found in the current NRCS PLANTS data base (see http://plants.usda.gov/plants) as a national standard or provide accurate translators to those names as a cross-walk. (PLANTS is a component of the Interagency Taxonomic Information System (ITIS) (http://www.itis.usda.gov/itis).

7.2. Metadata - Agencies should record and make available the required FGDC metadata during the course of vegetation inventory, whether data has been gathered via remote sensing or field work. This metadata includes but is not limited to:

- Metadata for Field (stand and plot) Samples:
  > Data Collectors: name and affiliation of investigators
  > Date of field work

  > Field Methods: plot design, date of observation/data collection, date of classification, [other field methods metadata?]

  > Geographic coordinates (UTM or latitude/longitude coordinates) of sample and the datum (NAD27 or NAD83); method of determination; and estimated locational accuracy information, in the form of +/- X m.

  > Sampling design: how, why, and how many sample sites were chosen (subjective, random, stratified, etc.)

  > Approximate extent of the stand sampled.

  > Where and how the data are stored.

- Metadata for Remotely Sensed Samples:
  > Type of imagery (TM, SPOT, aircraft scanner, radar, CIR, B&W, video, etc.)

Source (mono, stereo, vertical, oblique)

Scale or resolution of imagery

Date of imagery

Methods used to classify type

Method of imagery classification (visual or computer assisted)

Geographic coordinates (UTM or latitude/longitude coordinates) of sample and the datum (NAD27 or NAD83); method of determination; and estimated locational accuracy information, in the form of +/- X m.

7.3. Scale - The scale of data acquisition and presentation affects the resulting classification. When sponsored by a federal program, the classification, itself, must be done according to the NVCS scheme. The metadata that accompany the classification will have to discuss the influence of the chosen scales on the ability of the resulting classification to discriminate the smaller area vegetation types from the matrix of larger area vegetation types within which the smaller types are mixed. Any presentation should include metadata about the influence of scale on the nature or resolution of both the input data and the constructed or displayed product.

7.4. Management and Reporting of Vegetation Information Associated with Vegetation Maps

- The following metadata should be developed in conjunction with mapping efforts:
  a. Location and extent of mapped terrain.
  b. Map Scale
  c. Map legend and descriptors of the mapped units
  d. Criteria for minimum mapping units

- General Metadata
  a. Names and affiliations of people who collected the field data
  b. Level of vegetation classification that was used for the map
  c. Information about where the data are stored
  d. A description of the format in which the data are stored (GIS package, data base structure, etc.)
  e. A summary of accuracy assessment procedures (class and locational) that were used and the results. It should be noted that some plot data collected with the protection of data confidentiality, by legislation and law, will not be revealed.

8. UPDATING AND TESTING

The National Vegetation Classification Standard will be subject to periodic review and updates. It is necessary that the NVCS continue to improve with new information and knowledge about species assemblages across the landscape in relation to succession, disturbance, extinction, climate change, etc.

Through the Vegetation Subcommittees the USDA Forest Service will oversee maintenance and updating of the NVCS in collaboration with agencies, professional societies, and other organizations. The subcommittee will make arrangements for a data base manager who will effect changes to the master copy of the classification standard as well as conduct any routine maintenance on current versions. The frequency of updating and maintenance that will be necessary is presently unknown, although it is expected that the number and extent of changes to the system will dampen over time.

The purpose of this classification standard is to provide a hierarchical set of categories describing assemblages of plants. This particular standard should not be extended to uniformly include other discrete environmental parameters (such as climate, soils, geology, or physiography). Rather, these other categories of information can be correlated with classified vegetation types through use of common geographic coordinates, for example, by intersecting the desired sets of data using a GIS to yield a separate transformed spatial data showing the combined themes of interest.

An objective of these standards is to create a standard of repeatable classes of vegetation in which the units are both exhaustive and mutually exclusive at each level of the hierarchy. To insure potential for improvements to the standard there will be a period of operational testing and validation, providing an informed basis for any revisions in the future. The goal of this operational testing period is to identify and address any problems in implementing the classification standard. Since adherence to the NVCS will be mandatory for federal activities, the standards need to be applicable to all locations having natural, semi-natural, or cultivated vegetation.

The testing and validation of the physiognomic levels of the standard will consist of three parts: a) develop a dichotomous key for the standard; b) test the standard for being exhaustive and mutually exclusive; and c) "crosswalk" the standard to other existing standards. Each of these parts is explained below.

- A simple dichotomous key to the standard will be developed. The key will use the criteria already provided in the system. The objective of this part is to arrange the standard into a "tree" structure that could be followed by a novice, and which will be used in part B, below.

- Using existing ground plot data samples, verify that the equivalence classes in each level of the classification's hierarchy are both exhaustive and mutually exclusive. Then, classified samples from the following image sources will be tested for these same qualities (exhaustive and mutually exclusive): a) aerial photographs at a nominal spatial scale of 1:24,000; b) Landsat Thematic Mapper satellite imagery at a nominal spatial scale of 1:100,000; and c) AVHRR satellite imagery at a nominal spatial scale of 1:1,000,000. Results from testing the classification standard with data from these sources will be compared and these results will be used to recommend improvements to the standard. Although the testing and validation activity need not generate large amounts of new data, since many usable data sets exist already, some original field work will be necessary. From this exercise, the subcommittee will determine how well the standard can characterize vegetation types across each level of the hierarchy from ground plot data, aerial photography, and satellite imagery. From this initial testing, improvements to the standard may be made.

- Compare, or "crosswalk," the NVCS with other existing classification standards that have regional or state, or national applications. This "crosswalking" may provide a means to identify possible shortcomings in the NVCS. However, the importance of the "crosswalking" activity will be to facilitate applications of the NVCS to previous work done using other standards. The "crosswalking" will be

produced in a database format that includes the map codes for each classification standard in order to facilitate greater automated translation among computerized map products.

The operational testing period will test the classification at a number of sites across the United States to gage the system's functionality among different geographic and ecological regions and gradients. Testing will include, but not be limited to the following range of regions and vegetation types: row crops, cereal crops, tree plantations, tundra, sub tropical scrub forests and marshes, shrub steppe, deserts, mixed graminoid and shrub vegetation, and coniferous forests grading into seasonally deciduous forests.

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10. APPENDICES